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(71) Applicant(s)
Sofitech N.V.
(Incorporated in Belgium)
Rue de Stalle 142, B-1180 Brussels, Belgium

(72) Inventor(s)
Edward K Leugemors
William R McIntyre

(74) Agent and/or Address for Service
B D Stoole
Geco-Prakla (UK) Limited, Schlumberger House,
Buckingham Gate, GATWICK, West Sussex, RH6 0NZ,
United Kingdom

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(54) Abstract Title

Jet mixer for oilfield cement slurry with a divergent liquid stream

(57) A jet mixer comprises a liquid stream spray nozzle 61; a mixing zone in front of the nozzle 61 where liquid from the nozzle contacts cement supplied from a hopper input 63; and a discharge barrel 62. To reduce build-up of caked cement (bridging) caused by splashback of slurry and blowback of air (see figure 1 and 2) around the mixing zone and hopper input 63, the liquid from the nozzle 61 has a divergent stream so that it fills the barrel 62 before it reaches the end distal to the nozzle 61. An annular water flow (106, figure 7) may also be provided from an annulus around the nozzle to further mix with the slurry 107. Further embodiments include a barrel which is divergent (figure 6) or the inclusion of inserts (50, figure 3, and 71, 72 figure 5) in the barrel.

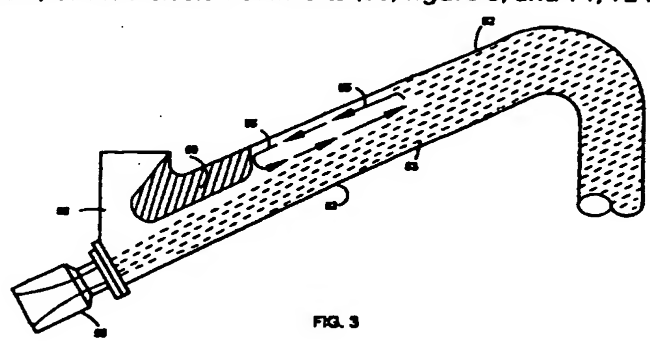

FIG. 3

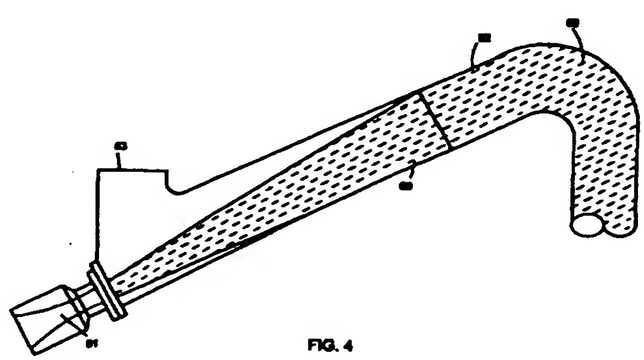

FIG. 4

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This print incorporates corrections made under Section 117(1) of the Patents Act 1977.

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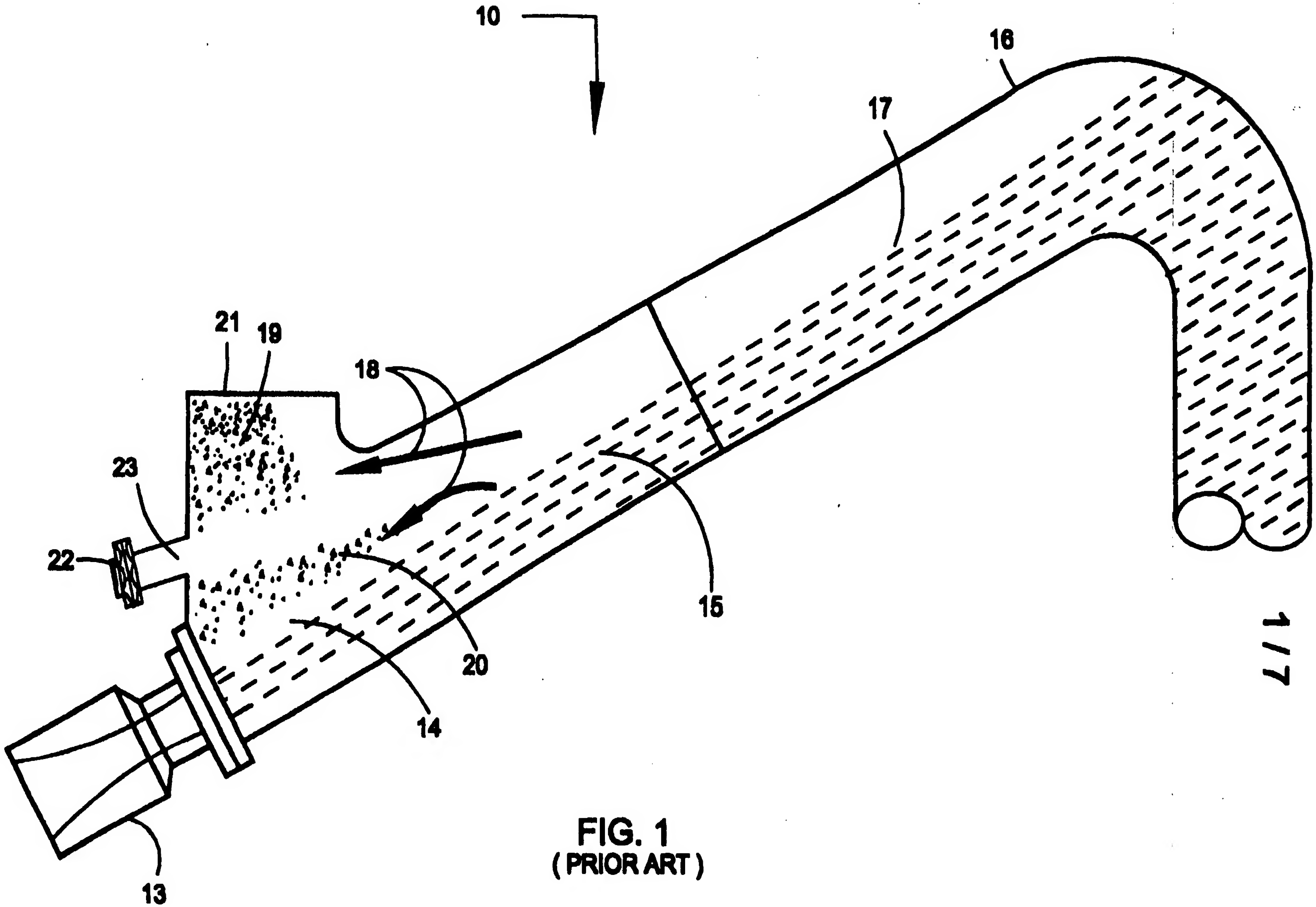

FIG. 1
(PRIOR ART)

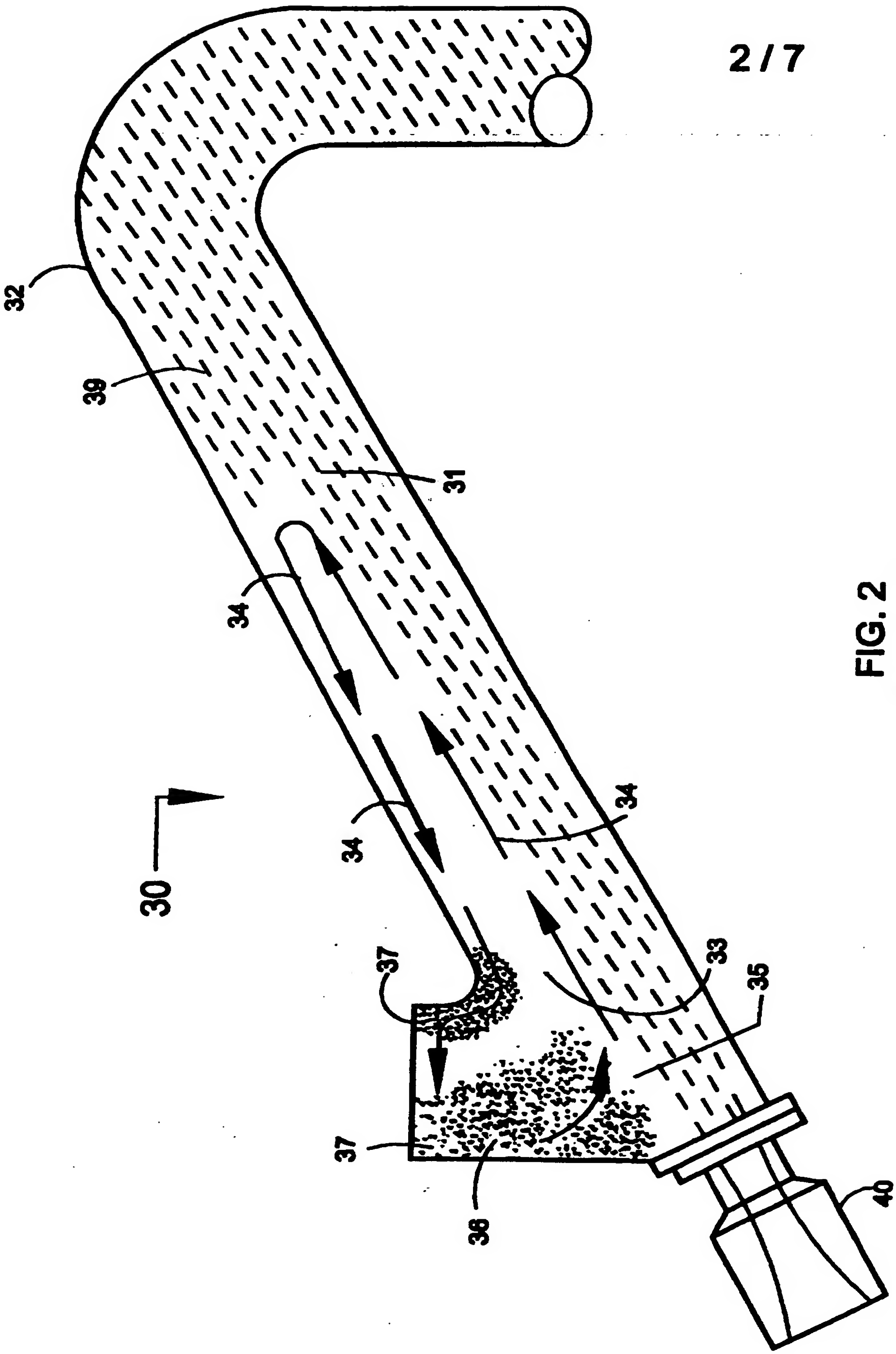

FIG. 2
(PRIOR ART)

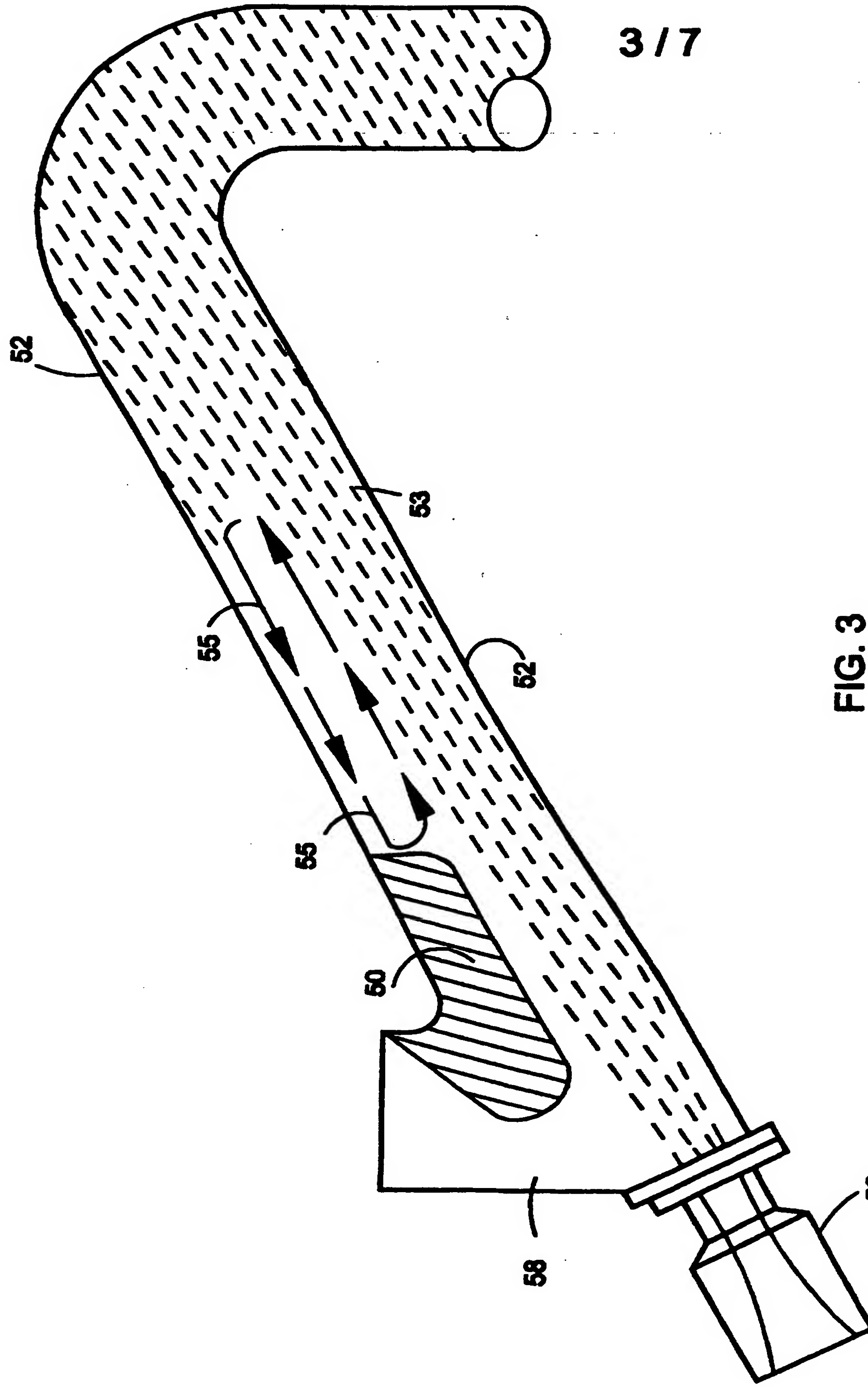

FIG. 3

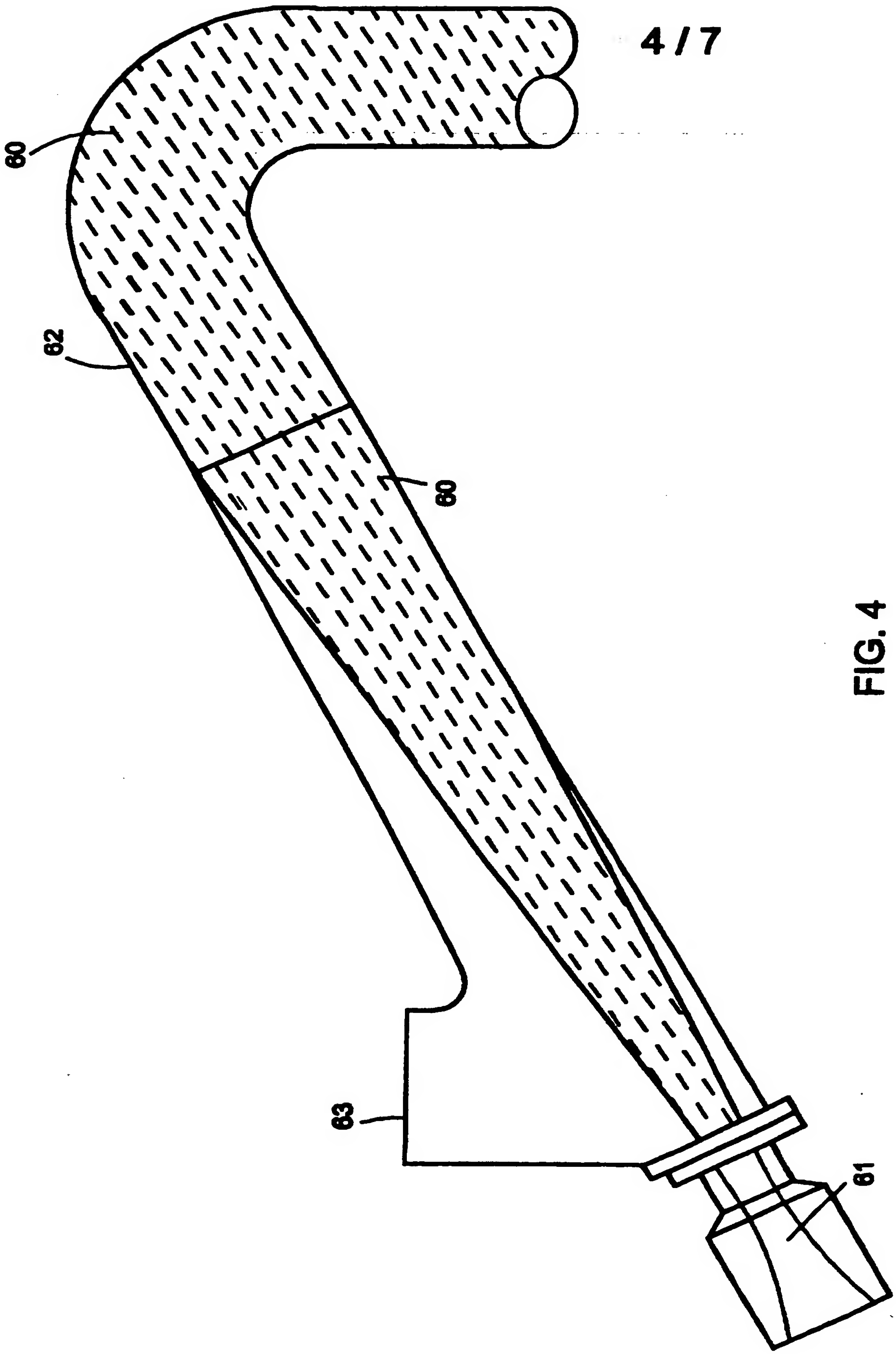

FIG. 4

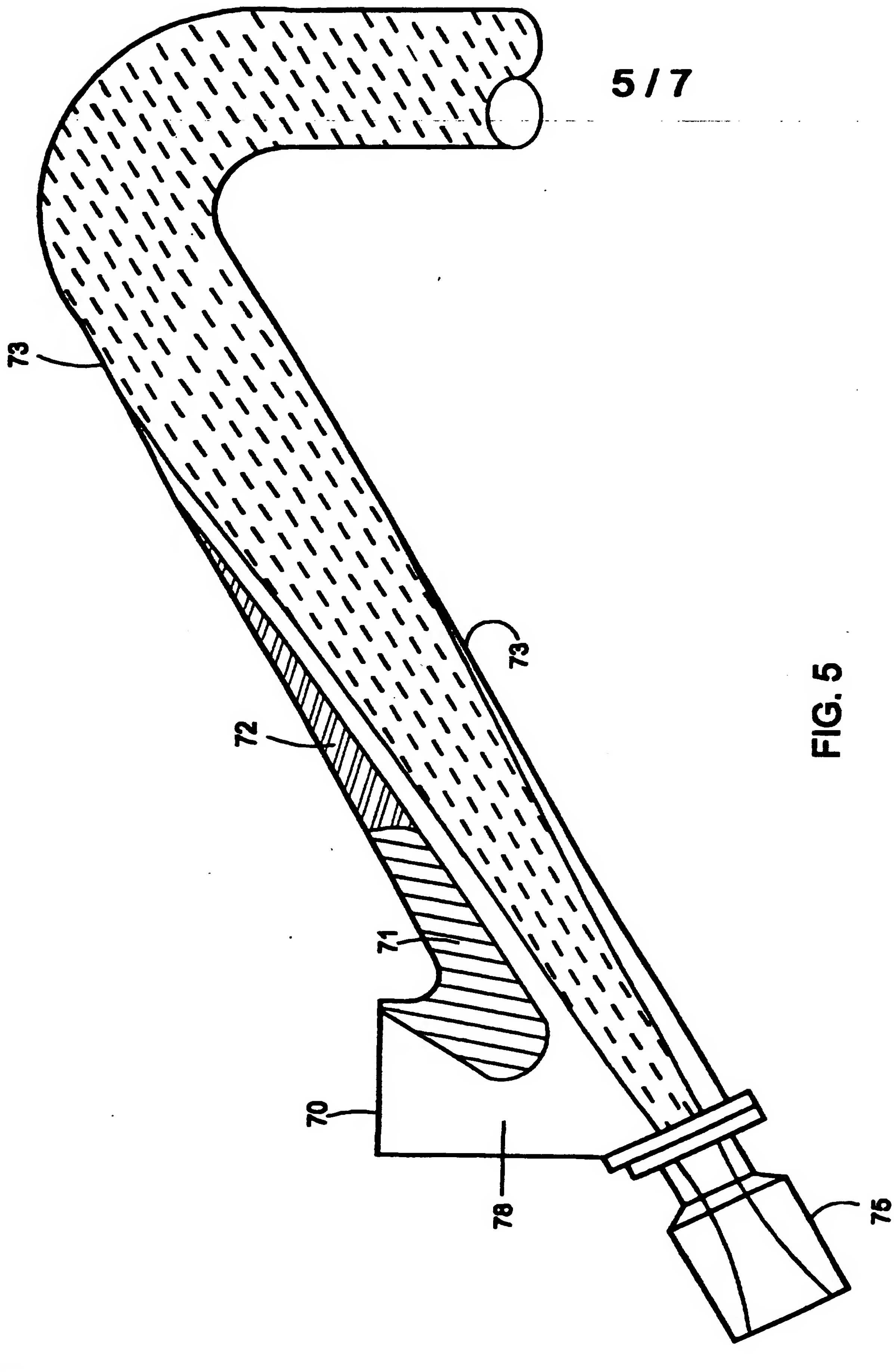

FIG. 5

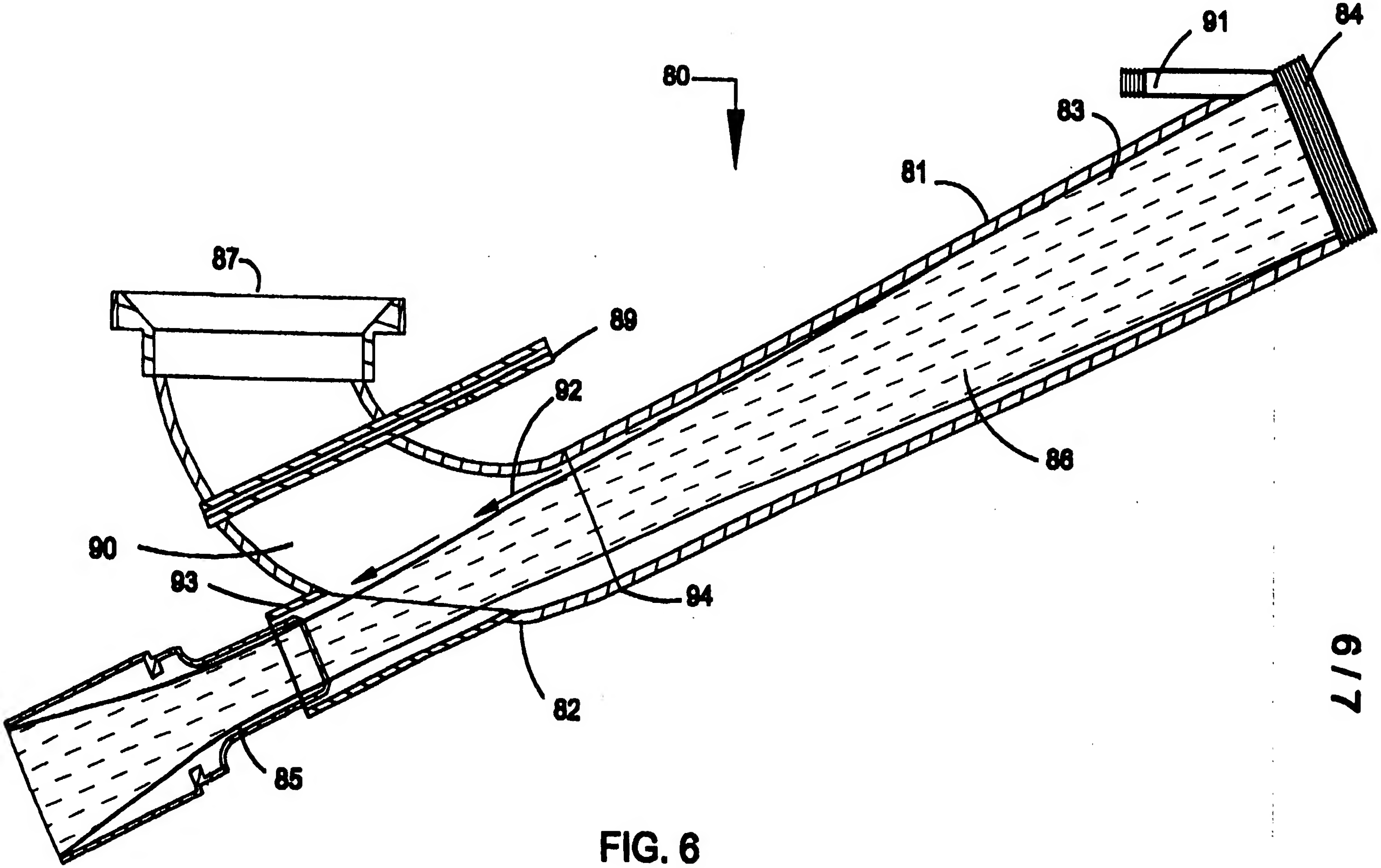

FIG. 6

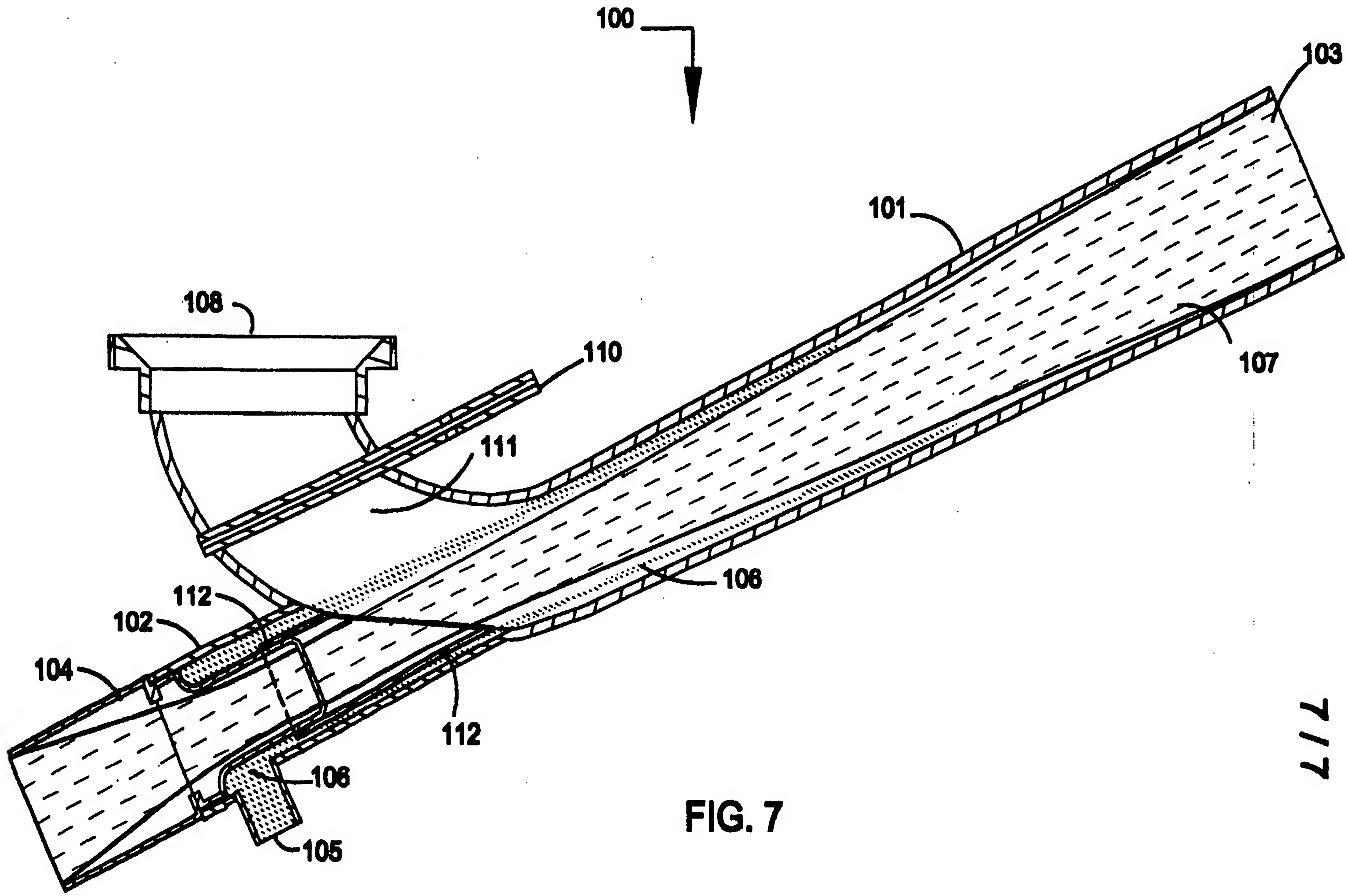

FIG. 7

MIXING METHOD AND APPARATUS

BACKGROUND OF THE INVENTION

Field of the Invention

This invention relates to high speed mixing. In particular, the invention relates to apparatus and methods for mixing oilfield cement slurries at high rates for cementing wellbores.

Description of the Prior Art

The cementing of wellbores for land based and offshore oil and gas operations requires a reliable and homogenous source of cement. Dry cement typically is delivered to a wellsite, provided to a cement mixer, combined with water in the mixer, and pumped downhole to solidify in a wellbore. In many cases, the slurry is recirculated within the mixing apparatus prior to pumping the mixture downhole.

Mixing and pumping cement at a high rate of speed is desirable to conduct service operations as quickly and efficiently as possible, so that the well can be placed on line for oil and gas production. If cement is mixed and pumped faster, substantial savings are achieved. Problems with cementing occur when cement builds up or cakes in the interior of the mixer. Such build-up of partially wet cement can become a hard and relatively impermeable mass -- blocking the flow of dry cement into the mixer. In such cases, this blockage undesirably reduces overall dry cement flow rate, thereby reducing the overall cement slurry output rate.

Jet mixers for combining dry cement with a liquid use the power in a liquid jet to entrain and mix the dry cement with liquid. Air inherent in the dry cement is separated from the resulting cement and liquid slurry, and the slurry usually is pumped down oil or gas wells

to cement casing in place. The liquid may be water, cement slurry re-circulated through the mixing system, or other desired liquid. In the past, oilfield cement jet mixing has been accomplished primarily using straight jets sprays, that is, using a spray that has margins that are roughly parallel.

Generally, there are two rate limitations for jet mixers. First, there is an initial mixing rate limitation based upon the size and velocity of the liquid jet and the geometry of the mixer system. Second, there is a rate limitation that occurs when the mixing area becomes partially filled or blocked with a buildup of partially wetted, dry cement adhering to walls of the mixer.

When mixing commences, the initial mixing rate usually is the maximum achievable rate. As mixing continues with prior art mixers, liquid from the jet may undesirably splash back and wet the inside surfaces of the mixer. As dry cement enters the mixer, the cement contacts and adheres to the wetted surfaces inside the mixer and accumulates, thereby restricting or blocking the passage of cement to the fluid stream.

A significant portion of such splash-back is caused by air re-circulation within the mixer. When the jet slows in the gun barrel, the pressure in the barrel is higher relative to the mixing zone, and air recirculates back to the lower pressure in the mixing zone. In prior art devices, this recirculating air carries slurry back to the mixing zone where it wets the walls. Build-up of materials within the mixing area of the unit eventually results from the blowback of the slurry into the mixing zone. This build-up restricts the flow of fresh cement into the mixer and reduces the achievable mix rate. Better eduction of dry cement and air in the mixing zone lowers the pressure, and reduces air recirculation and splashback of liquid or blowback of slurry, thereby reducing potential material build-up.

Build-up of partially wetted material in the mixer is particularly detrimental in oilfield cementing applications. The oilfield mixing process is typically a continuous mixing process. To clean build-up from the mixer requires interrupting the mixing process and delaying the cementing application. Furthermore, oilfield cementing rates are typically much higher than powder mixing rates in other industries leading to more rapid build-up accumulation. Thus, it is important that mixing occur efficiently at high rates. These facts make it even more critical that mixing occur at high rates in an efficient manner.

What is needed is an apparatus and method of cementing that facilitates a high rate of cement mixing with reduced build-up of material within the mixer. A cement mixer design reduces air recirculation or blowback of slurry from the slurry stream back into the mixer is highly desirable. Reducing build-up of material within the mixer reduces the time and cost required for cementing operations.

SUMMARY OF THE INVENTION

The invention comprises an apparatus and a method for mixing a particulate composition with a liquid. In many cases, the liquid is an aqueous solution containing water. The apparatus comprises a spray nozzle, the nozzle being capable of forcing a liquid stream into close contact with a particulate composition. Also provided is a mixing zone, wherein the particulate composition contacts the liquid stream combining to form a slurry. Further, a barrel is included having a proximal end and a distal end, the proximal end of the barrel being in liquid communication with the mixing zone, wherein the blowback of slurry from the barrel to the mixing zone is reduced. In normal operations, the slurry proceeds from the proximal end of the barrel to the distal end of the barrel.

In one embodiment, the barrel diverges from a smaller diameter at its proximal end to a larger diameter at its distal end and contains an insert to restrict slurry blowback to the

mixing zone. In another embodiment, the liquid stream exits the nozzle in a diverging pattern as it passes along the interior of the barrel. In another embodiment, the barrel diverges and the liquid stream exits the nozzle in a diverging pattern. In another embodiment, water exits a water line in an annulus surrounding the nozzle from which the liquid stream exits in a diverging pattern.

A method of mixing cement is disclosed in which a mixing apparatus is provided, the apparatus having a nozzle, a mixing zone and a barrel. The nozzle typically is oriented to emit a liquid stream into the mixing zone, the mixing zone being in liquid communication with the barrel. The mixing zone further includes an input for dry cement. During operation, liquid flows through the nozzle and mixes with the dry cement to form cement slurry. Then, the cement slurry is delivered into the barrel.

BRIEF DESCRIPTION OF THE DRAWINGS

The following Figures are provided to further illustrate the invention:

Figure 1 depicts a prior art configuration in which a non-diverging barrel design undesirably results in cement slurry build-up or caking within the interior of the mixer;

Figure 2 depicts a prior art configuration in which interaction of a straight liquid stream with the barrel walls undesirably results in re-circulation of air.

Figure 3 shows one aspect of the current invention including non-diverging fluid stream with an insert to restrict blowback to the mixing zone;

Figure 4 is one aspect of the invention using a diverging liquid stream to educt the cement/air mixture;

Figure 5 shows another embodiment of the present invention showing a change in the shape of the interior of the mixer at the junction of the mixing bowl and barrel, which suppresses air recirculation;

Figure 6 depicts another embodiment of the invention including a diverging barrel and a diverging liquid stream; and

Figure 7 depicts a preferred embodiment of the invention including a diverging barrel, a diverging liquid stream and addition of water to the annulus surrounding the liquid stream.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

A prior art mixing device **10** is shown in Figure 1. The device shown in Figure **1** is similar to current mixer designs in use today, such as for example the CPS361 Caterpillar CBS393 "Slurry Chief" mixer (Slurry Chief is a trademark of the Schlumberger Technology Corporation). In Figure 1, the prior art device **10** has a nozzle **13** that emits a stream into mixing zone **14**. Slurry spray **15** proceeds long the converging barrel **16** where it exits the unit. Slurry spray **15** is shown in Figure 1 with no divergence due to interaction with the interior walls of barrel **16**. The upper bounds of the slurry spray **17** can emit blowback of air and splashback of slurry along pathways **18** in reverse direction. This undesirable blowback and splashback causes cement build-up **19**, also known in the industry as "bridging". The areas of cement build-up **19** and cement bridging **20** on Figure 1 represent large amounts of undesirable cement build-up within the interior of the device. Such build-up of wet cement greatly slows the passage of dry cement through gate **21**, which in turn greatly slows the overall rate at which the unit can process cement slurry as output. Cement buildup **19**

further clogs the passageway for dry cement into the mixing zone **14**. Cement bridge **20** is formed just outside the high pressure slurry spray **15** which proceeds along beside the bridge **20**. On some units, optional water input **22** provides water line **23**, which sprays water into mixing zone **14**.

The conventional straight water spray **15** is shown within barrel **16**, and it can be seen that the water spray is not centered in the barrel, but proximate to one margin of the inner surface of the barrel. Further, the slurry spray stays essentially parallel (neither diverges nor converges to a significant extent) along the length of the barrel. The non-divergent liquid stream has been found to be less efficient at educting and mixing dry powder with the liquid stream. In the prior art device using a straight stream, there is minimum stream surface area, and less interaction of the stream with cement and air in the volume surrounding the stream. The interaction of the stream with the barrel inner surface influences liquid flow within the barrel and the eductive effect.

In Figure **2**, a cross-sectional area of a prior art mixer **30** with nozzle **40** shows the volume occupied by the liquid stream **31** after interaction with the barrel walls **32**. Interaction of the stream with the barrel walls **32** cause the liquid stream **31** to diverge and eventually fill the entire barrel **39** near the end of the barrel. Further, the air space **33** contains recirculated air which flows along pathways **34** and competes with incoming air and cement for space near the educting liquid stream. The air recirculation causes build-up of wet cement in the mixing zone **35**, which causes operational problems. Restricted dry cement flow path **36** is undesirably choked by cement build-up **37**.

Figure 3 shows one embodiment of the present invention in which an insert 50 is applied into a mixer such as shown in Figure 2. The insert is a device specifically shaped to fill the void within the mixing cavity of a prior art mixer to reduce undesirable air recirculation 55 back into the mixing zone 58. The insert is shown applied in the barrel proximate to mixing zone 58, although its exact location could vary. Nozzle 56 emits a fluid stream 53 into barrel 52. Mixing zone 58 is kept relatively clear of cement build-up because of the blowback air-flow restriction of insert 50. Cement slurry that may be blown back from the barrel 52 towards the nozzle 56, if at all, may be trapped behind a pipe wall surrounding nozzle 56.

Figure 4 illustrates another aspect of the present invention that employs a diverging liquid stream 60. Dry cement is added through input 63. The diverging stream is smaller near the nozzle 61 and larger near the distal end of the barrel 62. The liquid stream is shown to diverge to occupy the full area of the barrel proximate to the distal end. After that point, the liquid stream 60 contacts the full perimeter of the barrel 62.

Figure 5 shows another aspect of the present invention in which the shape of the interior of the mixing zone 78 near dry cement input 70 reduces air recirculation in the mixer. A two-part insert system --inserts 71 and 72 within barrel 73 reduces undesirable air recirculation back into the mixing zone 78. Cement slurry that is blown back from the barrel towards the nozzle, if at all, may be trapped behind a pipe wall surrounding nozzle 75. A water line may provide annular water flow around the high-pressure liquid or slurry stream emitted from nozzle 75.

Another embodiment of the present invention is shown in Figure 6. In this embodiment, the mixing apparatus 80 advantageously includes a diverging barrel 81. The cross-sectional area of the barrel increases from the proximal end adjacent nozzle 82 to its distal end 83 near exit 84.

Nozzle 85 provides a high-pressure liquid or slurry stream. The liquid stream 86 diverges and expands as it travels from the nozzle 85 along the diverging barrel 81. Preferably the liquid stream 86 expands in a full cone jet. Dry cement is added through input 87 and may be selectively admitted by gate 89 to the mixing zone 90. The mixing zone 90 is the first contact point for liquid/slurry coming from the nozzle 85 to meet with dry cement. Diverging liquid stream 86 proceeds along the diverging barrel 81 to exit 84. Optionally, an additional liquid line 91 may input water or re-circulated slurry near the distal end 83 of the diverging barrel 81. Preferably, the diverging liquid stream 86 contacts the full inner perimeter of the barrel nearer the distal end of the barrel 83 than the proximate end of the barrel adjacent to nozzle 85.

Slurry blowback is diminished using the design as shown in Figure 6. Cement slurry that is blown back from the barrel towards the nozzle 85, if at all, proceeds along pathways 92 in a direction that largely avoids build-up or caking of cement in the mixing zone 90. Further, slurry blowback that proceeds along pathways 92 favorably is trapped behind pipe wall 93 and mixes into the liquid stream 86. Wetting of the mixing zone 90 walls is minimized, resulting in a greater throughput of dry cement and greater slurry mixing rate.

Another preferred embodiment of the present invention is shown in Figure 7. In this embodiment, the mixing apparatus 100 advantageously includes a diverging barrel 101. The

cross-sectional area of the barrel increases from the proximal end adjacent to the nozzle **104** to its distal end **103**.

Housing **102** connects to nozzle **104** that provides a high-pressure liquid or slurry stream. Water line **105** provides annular water flow **106** around the high-pressure liquid or slurry stream emitted from nozzle **104**. Preferably, the liquid stream **107** diverges and expands as it travels from the nozzle **104** along the diverging barrel **101**. Most preferably, the liquid stream **107** diverges and expands into a full cone jet. Dry cement is added through input **108** and may be selectively admitted by gate **110** to the mixing zone **111**. The mixing zone **111** is the first contact point for liquid stream coming from the nozzle **104** to meet with dry cement. Liquid stream **107** proceeds along the diverging barrel **101** to distal end **103**. Cement slurry that is blown back from the barrel towards the nozzle, if at all, may be trapped behind a pipe wall **112** surrounding nozzle **104**.

EXAMPLES

Mixing rates depend on the mixing system which contain, among other elements, mixer components such as those described in this application. To describe the improvements over conventional jet mixing systems, we provide comparisons of field mix rates and test mix rates with conventional and improved jet mixers. These tests are performed with similar conditions regarding the remainder of the mixing system: specifically the type of recirculation centrifugal pump and the speed of operation. The mix rate is generally limited by the maximum rate at which dry materials can be ingested by the mixer.

Example 1
Mixing Bowl Build-up

The current mixer in field application had a build-up of slurry within the mixer to the point that the mixing operation was shut down to clean up the interior of the mixer to continue mixing. This failure occurred for systems with gypsum as an additive to any class cement. Shutdown was required after every 50 to 100 barrels of cement slurry. Also, Class A cement occasionally caused the same problem.

Example 2
Enhanced Build-up Test with Conventional Mixer

Three-hundred (300) sacks of Class A neat cement at 15.4 pounds per gallon density were mixed at 2 barrels per minute ("BPM") for low mixing bowl pressures. This rate of mixture enhanced air re-circulation and blowback of slurry. The mixing bowl level was controlled by variations in the triplex pump speed. The same centrifugal pump that was used to run the re-circulating mixer also supplied the triplex pump. By varying the triplex pump rate, the flow rate through the re-circulation nozzle was varied and the conditions in the mixer modified. Alternating wet and dry areas were created in the mixing bowl. When the triplex pump shifted gears, it momentarily stopped pumping which greatly affected the conditions in the mixer and led to undesirable build-up in the mixing bowl.

After mixing 300 sacks of cement with the conventional mixer under the conditions described above, cement build-up filled over one-half of the mixing bowl volume and restricted flow of dry cement into the mixing bowl. With restricted flow, the maximum

mixing rate was only 6 BPM with Class A cement at 15.2 pounds per gallon ("PPG"). Before the build-up test, the slurry could be mixed at 6.4 BPM.

Example 3
Enhanced Build-up
Test with Improved Mixer

Following the same procedure as above in Example 2, three hundred (300) sacks of Class A neat cement were mixed at 15.4 PPG density. Mixing occurs at 2 BPM for low bowl pressures. Varying the triplex pump speed controlled the mixing tub level. In this example, there was no build-up in the mixing bowl, and no reduction in maximum cement rates. The improved mixer processed Class A cement at 8 BPM or more.

Example 4
Extreme Case for Build-up Testing:
60% Gypsum and 40% Class H Cement

In field applications, when build-up in the mixer bowl restricts the dry solids input rate to provide only 2 BPM as the mixing rate, mixing is stopped to clean the equipment. When the cement slurry is comprised of a 60/40 Gypsum-cement blend, the mixing bowl build-up restricts the mixing rate to that extent after pumping only 50 to 100 BBL of slurry.

To test the new mixer design, the Gypsum slurry mixing conditions were made more difficult than field conditions in three ways. First, the initial mixing rate was at a low 2 BPM, creating low mix bowl pressures, which promoted high air re-circulation rates back to the mixing bowl. Second, the triplex pump rate was changed by shifting pump gears and the change in rate led to varying slurry re-circulation rates through the mixer. This tended to

wet the ideally dry parts of the mixer bowl. Third, the gypsum/cement slurry was mixed using only one-third the required amount of retarder. The measured setting time for the slurry was only 7 minutes. The low rate mixing continued for 30 minutes at 2 BPM. At that time 60 BBL had been pumped under extreme build-up conditions. Then the mixer rate was increased to determine the maximum mixing rate possible. At first the maximum mixing rate at which slurry density of 15.4 PPG could be achieved was 4 BPM. There was some build-up in the new mixer bowl restricting dry materials flow. Then, the dry material eroded the build-up. The achievable rate rose to 5 BPM, and then 6 BPM. The test was ended after reaching 6 BPM. Higher rates were not attempted. If the initial mix rate were 6 BPM, instead of 2 BPM, there would have been no decrease in rate due to build up with the 60/40 Gypsum-cement blend.

Example 5
High Mixing Rates Achieved
<u>With the New Mixer Design</u>

Using the conventional mixer, the maximum achievable rate for mixing Class H neat cement at 16.4 PPG was 6.4 BPM, before any cement build-up occurred, using a particular configuration in which the recirculation centrifugal pump also fed the triplex pump. The recirculation flow rate decreases when the mix rate (triplex rate) increases. All the rate test results given below were achieved with that same system configuration.

Several tests were run to determine mixing rates for a series of slurries with high solids content including some which are notoriously difficult to mix. These included:

1. Class H neat cement at 16.4 PPG

2. Class H cement + 35% Silica flour + 0.3% D65 at 17.0 PPG

3. LiteCRETE at 12.4 PPG ("LiteCRETE" is a trademark of Schlumberger Technology Corporation).

All additive concentrations given are percentages by weight of cement. Below is the procedure used for each of the high rate tests:

1) Prepared 600 sacks of blended material.
2) Ran mixer under automated density control set for the appropriate slurry density.
3) Started mixing and pumping cement slurry at 6 BPM.
4) When density was maintained, increased mix/pump rate to 7 and then to 8 BPM.

In the case of each system tested with the improved mixer, the mixer maintained slurry rate and density when the mix/pump rate was 8 BPM. This rate was the limit of the test equipment. The triplex pump rate was the limiting factor, not the rate of the mixer. It is anticipated that with higher achievable triplex pump rates, the improved mixer will handle these slurries at mix rates in excess of 8 BPM.

Example 6
Tests of Mixer Capacity for
<u>Educting Cement at High Rates</u>

The effectiveness of a jet mixer system to educt air when run with water as the educting liquid is a good indication of the ability of the system to educt cement-air mixtures at high rates. Tests were run with different mixer and liquid stream configurations as described and illustrated in the figures of this application.

The cement inlet was sealed with a plate having a one-inch hole surrounded by a one-inch pipe collar welded to the top side of the plate. Air traveled to the cement inlet through a Dwyer brand one-inch rotometer and a one-inch ball valve between the rotometer

and the pipe collar. In addition to measuring the air-flow rates with the rotometer, pressure in the mixing bowl also was measured. The water was recirculated. A 5 inch x 6 inch centrifugal pumped water from the mix tub to the jet nozzle. The water stream flowed through the mixer and back to the mix tub. Air entrained into the water in the mixer broke out of the water in the mix tub, so only the water was recirculated.

The water flow rates were substantially equal in the different tests. Flow rates through different nozzles varied slightly, but not enough to affect the results presented below. Data on three configurations illustrates the enhancement of eduction capability through suppression of air recirculation.

In Case 1, a prior art mixer with a straight liquid stream was tested. The prior art system was not as effective in educting air and mixing the slurry. When the stream was directed down to contact the bottom of the barrel and adjusted to provide the maximum air flow rate and maximum bowl vacuum, the maximum values were about 50 to 55 SCFM and minus 8 inches of Hg vacuum. The air-flow rate was sensitive to the liquid stream direction. The liquid stream direction greatly affects the stream configuration after contact and interaction with the gun barrel walls.

In Case 2, the mixer in Figure 4 having a diverging fluid stream was tested. The educted air flow rate was less sensitive to the direction of the diverging liquid stream. The maximum air flow rate and mix bowl vacuum were about 65 SCFM at minus 10 inches of Hg vacuum.

In Case 3, the mixer shown in Figure 6 produced the highest air flow rates and greatest vacuums in the mixing bowl. These were 72 SCFM and minus 12 inches of Hg vacuum.

While the invention has been described with a certain degree of particularity, it is manifest that many changes may be made in the details of construction and the arrangement of the components without departing from the spirit and scope of this disclosure. Other embodiments beyond those specific examples cited herein have been suggested, and still others may occur to those skilled in the art upon a reading and understanding of this specification. All such embodiments shall be included within the scope of this invention.

CLAIMS

1. An apparatus for mixing a particulate composition with a liquid, comprising:

(a) a nozzle for providing a liquid stream in contact with a particulate composition,

(b) a mixing zone where said particulate composition contacts said liquid stream and particulate composition and liquid stream combine to form a slurry, and

(c) a barrel having a proximal end and a distal end, the proximal end of the barrel being in communication with the mixing zone, wherein said slurry proceeds from the proximal end of the barrel to the distal end of the barrel,

(d) wherein said liquid stream diverges.

2. The apparatus of claim 1 wherein the liquid stream contacts the full inner perimeter of the barrel nearer the distal end of the barrel than the proximate end.

3. The apparatus of claim 2 wherein said liquid stream is cone-shaped.

4. The apparatus of claim 2 in which the liquid stream comprises recirculated slurry.

5. The apparatus of claim 4 further comprising water flow in the annulus around said nozzle, wherein upon discharge from said nozzle said liquid stream combines with water flow.

6. The apparatus of claim 2 in which the liquid stream is about centered within the barrel.

7. The apparatus of claim 2 further comprising a pipe wall around said nozzle.

8. An apparatus for mixing a particulate composition with a liquid, comprising:

(a) a nozzle for providing a liquid stream in contact with a particulate composition,

(b) a mixing zone wherein said particulate composition contacts the liquid stream and particulate composition and liquid stream combine to form a slurry,

(c) a diverging barrel having a proximal end and a distal end, the proximal end of the barrel being in communication with the mixing zone, wherein said slurry proceeds from the proximal end of the barrel to the distal end of the barrel, and

(d) an insert used to reduce air flow from said barrel into said mixing zone.

9. The apparatus of claim 8 wherein said insert is removable.

10. The apparatus of claim 8 wherein said liquid stream comprises recirculated slurry.

11. The apparatus of claim 10 further comprising water flow in the annulus around said nozzle, wherein upon discharge from said nozzle said liquid stream combines with water flow.

12. The apparatus of claim 8 further comprising a pipe wall around said nozzle.

13. An apparatus for mixing a particulate composition with a liquid, comprising:

(a) a nozzle for providing a liquid stream in contact with a particulate composition,

(b) a mixing zone where said particulate composition contacts said liquid stream and particulate composition and liquid stream combine to form a slurry, and

(c) a diverging barrel having a proximal end and a distal end, the proximal end of the barrel being in communication with the mixing zone, wherein the slurry proceeds from the proximal end of the barrel to the distal end of the barrel,

(d) wherein said liquid stream diverges.

14. The apparatus of claim 13 wherein the liquid stream contacts the full inner perimeter of the barrel nearer the distal end of the barrel than the proximate end.

15. The apparatus of claim 13 wherein said diverging liquid stream is cone shaped.

16. The apparatus of claim 13 in which the liquid stream comprises recirculated slurry.

17. The apparatus of claim 16 further comprising water flow in the annulus around said nozzle, wherein upon discharge from said nozzle said liquid stream combines with water flow.

18. The apparatus of claim 13 in which the diverging liquid stream is about centered within the barrel.

19. The apparatus of claim 13 further comprising a pipe wall around said nozzle.

20. A method of mixing cement, comprising the steps of:

(a) providing a mixing apparatus of claim 1,

(b) passing a diverging liquid stream through said nozzle;

(c) mixing liquid stream with particulate composition to form a cement slurry; and

(d) delivering the cement slurry into barrel.

21. The method of claim 20 further including the step of:

(e) recirculating the cement slurry.

22. The method of claim 20 in which the rate at which the dry cement and fluid mix into slurry is at least 6 barrels per minute.

23. A method of mixing cement, comprising the steps of:

(a) providing a mixing apparatus of claim 8,

(b) passing a liquid stream through said nozzle;

(c) mixing liquid stream with particulate composition to form a cement slurry; and

(d) delivering the cement slurry into the diverging barrel.

24. The method of claim 23 wherein said liquid stream diverges.

25. The method of claim 23 further including the step of:

(e) recirculating the cement slurry.

26. The method of claim 23 in which the rate at which the dry cement and fluid mix into slurry is at least 6 barrels per minute.

27. A method of mixing cement, comprising the steps of:

(a) providing a mixing apparatus of claim 13,

(b) passing a liquid stream through said nozzle, wherein said liquid stream diverges when emitted from said nozzle;

(c) mixing liquid stream with particulate composition to form a cement slurry; and

(d) delivering the cement slurry into the diverging barrel.

28. The method of claim 27 further including the step of:

(e) recirculating the cement slurry.

29. The method of claim 27 in which the rate at which the dry cement and fluid mix into slurry is at least 6 barrels per minute.

The Patent Office

INVESTOR IN PEOPLE

Application No: GB 0009061.3
Claims searched: 1-7,13-22,27-29
Examiner: Brendan Churchill
Date of search: 3 July 2000

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.R): B1C (CPJA)

Int Cl (Ed.7): B01F (3/12, 5/04, 5/20)
B28C (5/02)
E21B (33/13, 33/138, 33/14)

Other: Online: EPODOC, JAPIO, WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
A	GB 2022430 A	(BLUE CIRCLE) see figure	-
A	GB 1461902	(MAMVRIISKY & LAPCHENKO) see fig 5	-
A	US 4690333	(FLÄKT) see fig 3 and column 5 line 62 to column 6 line 26	-

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.